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Effect of coil configuration parameters on the mechanical behavior of the superconducting magnet system in the helical fusion reactor FFHR

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FFHR depicts the conceptual design of an LHD-type helical fusion reactor that is being developed by the National Institute for Fusion Science. Several design mechanisms for FFHR have been investigated. For instance, FFHR-d1A is a self-ignition demonstration reactor that operates at a magnetic field intensity of 4.7 T and has a major radius of 15.6 m. FFHR-c1 is a compact-type sub-ignition reactor that intends to achieve steady electrical self-sufficiency and that depicts a high magnetic field intensity of 7.3 T and a small major radius of 10.92 m. For both types of FFHR, the shape and positional relation among the superconducting coils, a pair of helical coils with two sets of vertical field coils, are observed to be similar with each other. Such a relation is based on the coil configuration of LHD. The coil configuration is defined using an aspect ratio, a pitch parameter of the helical coil, the number and geometric position of the vertical field coil, and so on. There is an increasing demand to achieve an optimized coil configuration to anticipate the improvement in plasma-confinement conditions. However, there are a few investigations that study the effect of coil configuration on mechanical behaviors of the coil systems, including the support structure. In this study, the structural design of FFHR-c1 based on the fundamental set of parameters of coil configuration is depicted, which satisfies the soundness of the structure. Further, the effects of the coil configuration parameters on the stress/strain distributions are investigated. A multiscale analysis is performed simultaneously to facilitate a detailed investigation of the elements in the superconducting coil. Furthermore, the mechanical behaviors during the coil excitation process are evaluated based on the contact between the coil winding and the support structure.

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